Magnetic Resonance Imager

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SPI Projects are Co-Funded by the U.S. Department of Energy
Superconductivity for Electric Systems Program and Industry Partners

Superconductivity Partnership with Industry

A demonstration HTS coil and cryostat system developed jointly by Oxford and Siemens.

What are its Primary Applications?

Magnetic Resonance Imagers, or MRIs, have revolutionized medical diagnostic capabilities. They can eliminate the need for harmful x-ray examinations and exploratory surgeries, and the precise diagnostic results that can be obtained have reduced the length of hospital stays, the burden on medical staff, and the discomfort of patients.

Traditionally, these units have been massive, heavy, and uncomfortably confining machines that use tremendous amounts of electricity to generate the magnetic fields that are used to graphically analyze internal details of the human body. Recent advances in the technology have led to open-geometry MRIs that provide a patient with greater comfort during the procedure, but at the cost of even greater electricity consumption. MRIs have also been developed that use low-temperature superconducting (LTS) technology. However, these Niobium Titanium compounds must be refrigerated to temperatures close to absolute zero. These factors combine to make the capital cost of MRIs prohibitive to smaller medical facilities.

High temperature superconductors (HTS) have the potential to significantly reduce the cost of MRIs. The higher operating temperatures allow for alternative refrigeration technology (conduction cooling) which reduces electricity costs and allows greater flexibility in the geometry of the system.

What are the Benefits to Utilities?

Benefits of this technology to utilities are indirect. Superconducting MRIs offer substantially reduced electricity demands in comparison to traditional resistive coil MRIs. Oxford estimates the electric energy consumption of a typical resistive MRI unit to be on the order of tens of kilowatts (kW), and using superconducting wire in the magnet's coils has the potential to reduce that figure to about 6 kW. The reduced load means utilities are not required to invest in as much local infrastructure - the power lines and transformers that supply the MRIs with electricity. Many medical facilities are also equipped with emergency power generators, and use of HTS units may allow for magnetic resonance imaging operations during electrical emergencies.

However, in order to achieve these levels of energy savings, the more efficient superconducting MRIs must penetrate the marketplace.

Goal:
Build and operate a cost-effective, open-geometry MRI system using continuously melt-processed, dip-coated, high temperature superconducting tape.

Team:
Oxford Superconducting Technology (team leader)

Siemens Medical Solutions (system integration/testing)

Oxford Magnet Technology (magnet assembly)

SCI Engineered Materials (conductor development)

Los Alamos National Laboratory (conductor analyses)

National Renewable Energy Laboratory (conductor development)

Period of Performance:
6/1/2002 - 5/31/2005

Cumulative Project Funding:
Private $1.26 million (50%)

DOE $1.26 million (50%)

Total $2.52 million

What is it?
Magnetic Resonance Imagers, or MRIs, generate and interpret powerful magnetic fields that pass through a patient to develop a visual image of the organs and tissues on the inside of the body.

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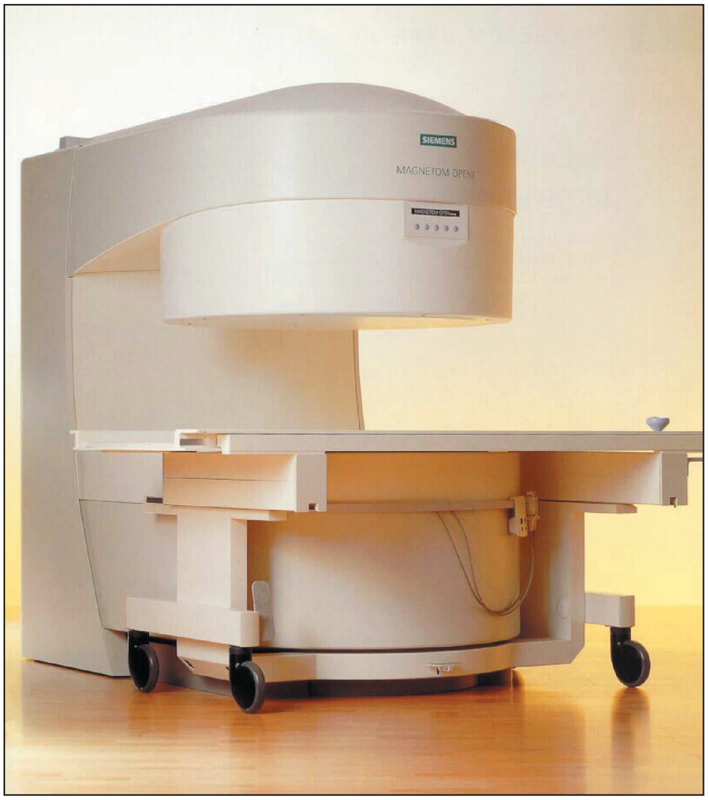

A typical open-geometry MRI can consume many kilowatts of electricity and weighs as much as 11 tons.

LTS MRIs can be expensive and their greater refrigeration needs limit the ability to open up the geometry of the device. Oxford envisions a less costly superconducting MRI using HTS coils and an open geometry that will gain a significant share of the market, allowing the efficiency benefits of superconducting MRIs to reduce infrastructure demands on utilities in more and more different locations.

What is the Market Potential?

Magnetic Resonance Imaging is already the largest existing market for superconductors. Industry experts have estimated the current worldwide MRI market at about $3 billion per year, and the market for MRI coils alone is expected to exceed $500 million by 2006.

What are the Project Accomplishments to Date?

This project was awarded in mid 2002, and conductor processing parameters are being developed. Oxford has previously completed the successful demonstration of two separate HTS coil/cryostat systems built with commercially available BSCCO-2223 tape. These demonstrations showed the feasibility of MRI-sized HTS coils and the ability to produce suitable magnetic fields. The next step will involve devising a more economical process to create BSCCO-2212 superconductors. The tapes will then be made into coils and demonstrated in an open-geometry MRI unit.

The initial design parameters of the project call for a device that produces a 0.2 Tesla (T) magnetic field. Ultimately, Oxford expects to produce a device generating a 0.5 T field. The device will use a GM-manufactured cryocooler and will operate at 20 Kelvins (K).

The first goal of the project will be to develop a magnet using the BSCCO-2212 conductor. Laboratory researchers at Oxford and many other companies continue to work towards developing better performing and lower cost superconductors. The next generation of superconductors is expected to emerge from a Yttrium-Barium-Copper Oxide compound called YBCO. The MRI magnet will be designed and engineered such that YBCO conductors can replace the BSCCO-2212 conductor if and when they become available. YBCO conductors will give the MRI better performance at a higher operating temperature.

How Does it Work?

The human body contains lots of hydrogen, much of it in the form of water. When the nuclei of hydrogen atoms — single protons, all spinning randomly — are caught suddenly in a strong magnetic field, they tend to line up like so many compass needles. If the protons are then hit with a short, precisely tuned burst of radio waves, they will momentarily flip around. Then, in the process of returning to their original orientation, they resound with a brief radio signal of their own. The intensity of this emission reflects the number of protons in a particular "slice" of matter. This emission can be interpreted by very complex software into a visual image of the subject.

The typical MRI scanner consists of a large magnet with a space in the center for the patient. This magnet aligns the hydrogen molecules of the body along its magnetic field. The patient rests on a table that slides into the opening in the magnet for completion of the scan.

What is the Status of the Project?

The project was awarded in mid-2002, and early efforts are focusing on processing parameters for the dip-coated superconducting tapes.

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